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AN ANALYSIS OF SEA SURFACE TEMPERATURE.(U)
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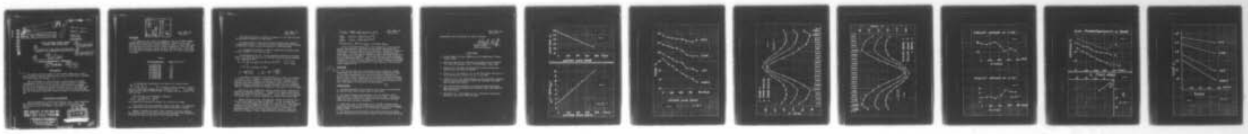

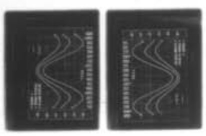

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Project No.
A-400-02-00
SR-104-03-01

NAVAL UNDERWATER SYSTEMS CENTER
NEWPORT, RHODE ISLAND 02840

(16) SR10403

(6) AN ANALYSIS OF SEA SURFACE TEMPERATURE.

(17) SR1040301

by

(10) Lloyd C. Huff

(9) Technical Memorandum No. ~~TA131-25-71~~

(11) 1 March 1971

(12) 12p.

INTRODUCTION

The monthly historical means of sea surface temperature in one-degree latitude/longitude squares along a line from Eleuthera to Bermuda are presented in this report. (cont on p. 4)

The data indicate a linear decrease in annual mean sea surface temperature of 0.4°C per 100 miles with a linear increase in variance of 0.85°C^2 per 100 miles as one proceeds from Eleuthera to Bermuda. Fourier series expansion of the data indicates that at least 97% of the data variance is contained within a one cycle per year cosinusoid and that the temperature variations along the range are essentially synchronous.

ADMINISTRATIVE INFORMATION

This memorandum was prepared under Project title: Deep Ocean Sonar Environmental Investigations, L. Huff, Principal Investigator. The Sponsoring Activity was NAVSHIPS, Code OOVIK, B. K. Couper, Program Manager.

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DISCUSSION

The data from this report was abstracted from the US NAVAL OCEANOGRAPHIC OFFICE publication 16782-GS (SUPP.1). Eight data sets were obtained for the one-degree squares listed in Table 1. These eight data sets represent the mean of the sea surface temperatures reported within the given square and month during the years 1854 thru 1953. This table also indicates the ranges from the southern end of a line from Eleuthera to Bermuda.

Table 1

Latitude/Longitude	Range (naut. mi.)
25-26N/74-75W	0
26-27N/72-73W	135
27-28N/71-72W	215
28-29N/70-71W	295
29-30N/68-69W	430
30-31N/67-68W	515
31-32N/65-66W	650
32-33N/64-65W	745

The annual mean temperature is the mean of the monthly means. $\overline{T} = 1/12 \sum_{i=1}^{12} T_i$. T_i represents monthly averages. Figure 1 presents annual mean temperatures as a function of the c[illegible]r-to-center range from the square 25-26N; 74-75W. A straight line was fitted to the points by eye.

The variance of the temperature defined as

$$\sigma_T^2 = \left[\frac{1}{12}\sum_{i=1}^{12} T_i^2\right] - \left[\overline{T}\right]^2$$

was computed and presented in Figure 2 as a function of range.

The original data were regrouped by month and range. The regrouped data comprised twelve families of sea surface temperature vs range.

Figure 3 presents the August, June, December, and March families. The individual data points are connected with segmented lines indicating a general decrease in temperature with increasing range.

The monthly historical average for ranges of 0, 300, and 745 miles are presented in Figure 4 as time series.

The data represent very long historical averages which approach climatological values. Therefore the value for any given month and year is identical in value for the same month but a different year.

It is apparent from Figure 4 that the temperature variations have a large component of one cycle per year.

A representation for the cosine components contained in the data from 1 to 6 cycles per year can be obtained by Fourier series expansion of the temperature data.

$$T = \overline{T} + \sum_{i=1}^{6} [A_i \cos(\omega_i t) + B_i \sin(\omega_i t)] \qquad \omega_i = i\omega_0, \quad \omega_0 = 1\text{cpy}$$

$$= \overline{T} + \sum C_i \cos(\omega_i t + \phi_i)$$

$$C_i = \sqrt{B_i^2 + A_i^2} \quad ; \quad \phi_i = \tan^{-1}\left(\frac{B_i}{A_i}\right)$$

A systematic evaluation of the distribution of energy is presented in Figures 5 and 6. Figure 5 illustrates the percent variance in the one cycle per year component as a function of range. Straight line segments were used to connect the individual points and it is observed that the variance represented is greater than 97% of the data variance. Figure 6 illustrates the percent variance at two cycles per year vs range.

The A_1, B_1, C_1, coefficients from the Fourier series expansion are graphically displayed in Figure 7. Straight line segments were used to connect the points in the A_1 and B_1 plots. The C_1 curve is sufficiently well behaved that it could be expressed as a linear function of range.

Figure 8 plots A_1 vs B_1. The angle α between the vertical and a line from the origin to a point is $(\phi - 90^\circ)$. It was concluded that $\phi = 145^\circ$ was adequate to represent the phase of the cosine temperature cycle per year component contains less than 3% of the total data variance in any given one degree square, it will be neglected in a simplified model of the sea surface temperature along the range from Eleuthera to Bermuda. Such a simplified model would be expressed as

$$T(t,R) = \overline{T}(R) + A(R)\cos(\omega t + 145°)$$

$$\overline{T}(R) = 25.60 - R(0.40 \times 10^{-2})$$

$$A(R) = 2.65 + R(2.38 \times 10^{-3})$$

t denotes time, R denotes range, ω denotes 1cpy

If this model were evaluated at time equivalent to mid month for August, June, December, and March the sea surface temperature as a continuous function of range could be predicted. Comparison of Figure 9 with Figure 3 indicates general agreement between the model and the actual data. Any discrepencies between the model and measured data are to be considered as anomalies. Continuous time series plots generated from the simplified model for ranges 0, 300, and 745 miles are presented in Figure 10. These plots are comparable to those of Figure 4 and demonstrates the ability to approximate the actual data by a constant plus a single weighted cosine.

CONCLUSION

(cont fr p. 1) 2

The discrete data sets representing monthly average sea surface temperatures have been filtered by Fourier series expansion and found to be closely approximated by a continuous function comprised of a constant plus a single weighted cosine of frequency one cycle per year. The one cycle per year temperature variations for the various locations were determined to be synchronous and to comprise 97% or greater of the total data variance in any given one-degree square.

CONTRADICTIONS

1. The data publication did not indicate the variance associated with the monthly means used as input data for this study.

2. The single frequency representation does not exhibit a narrow summer peak nor a broad winter minimum as does the data. A two cycle component would be required to improve the wave form shape agreement between the model and the actual data.

3. Recent data from IR overflights as well as XBT and towed sensor crossections between Eleuthera and Bermuda indicate large scale instantaneous spatial variability of the sea surface temperature.

4. The simplified model provided by this study should not be tasked beyond establishing a fixed reference against which buoy data and cruise

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measurements can be projected for their reporting.

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Electrical Engineer

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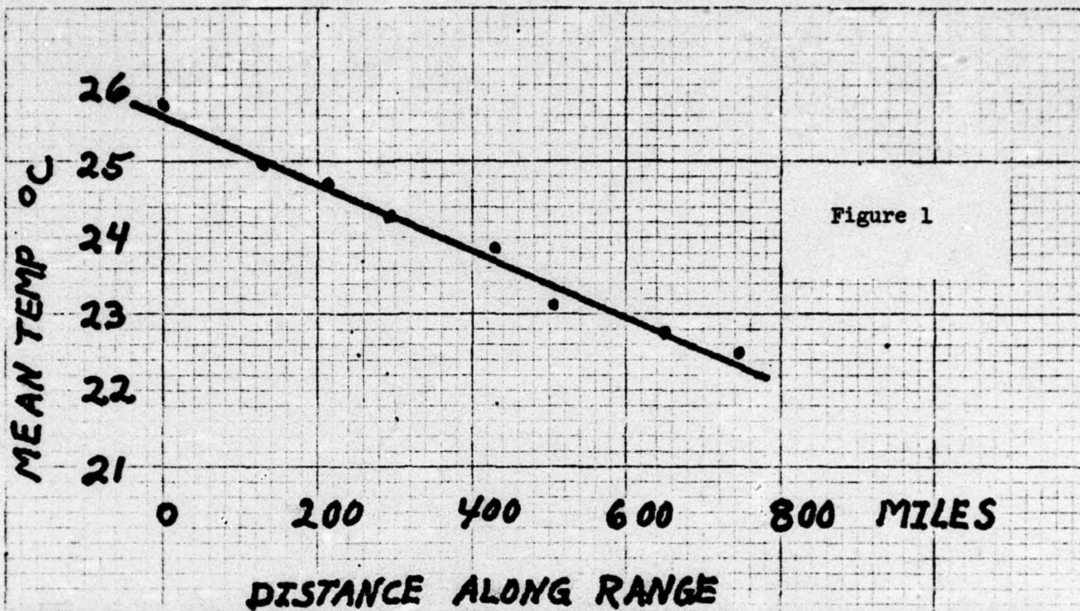

Figure 1

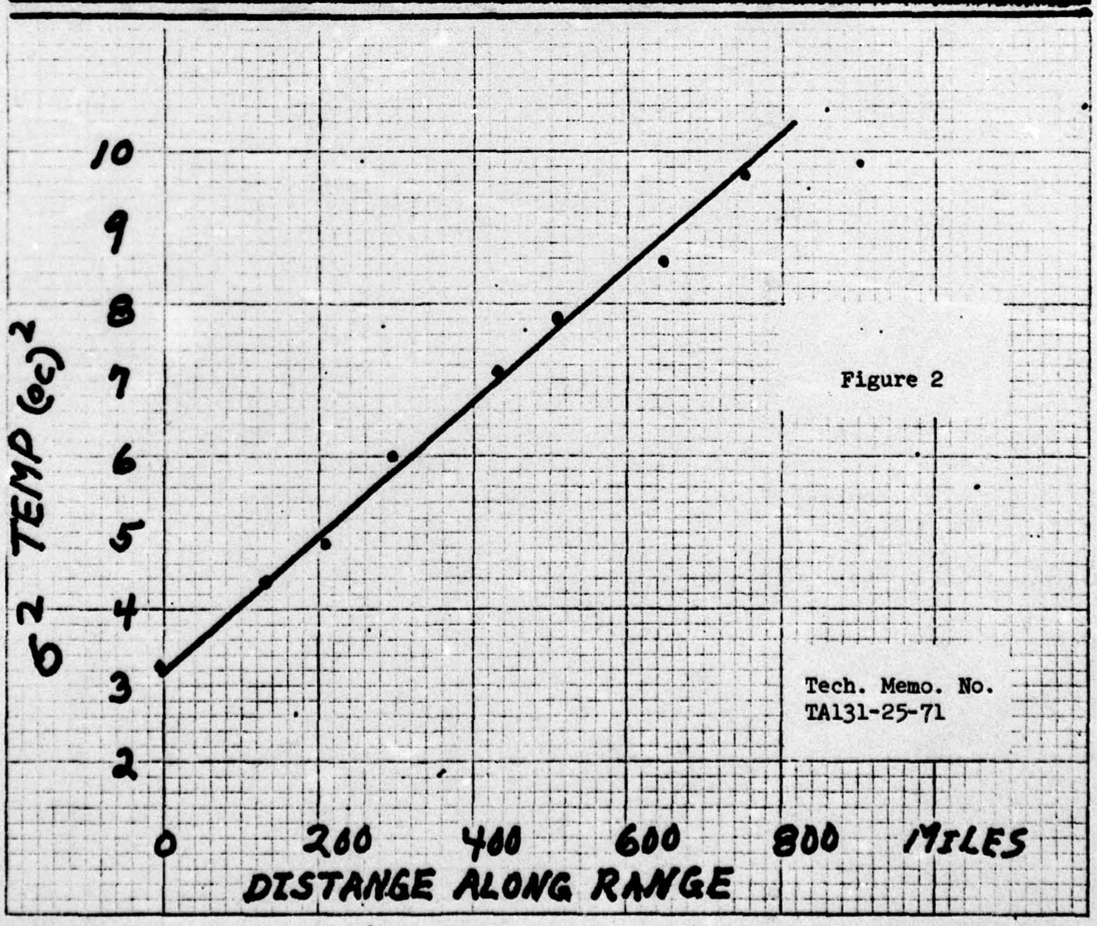

Figure 2

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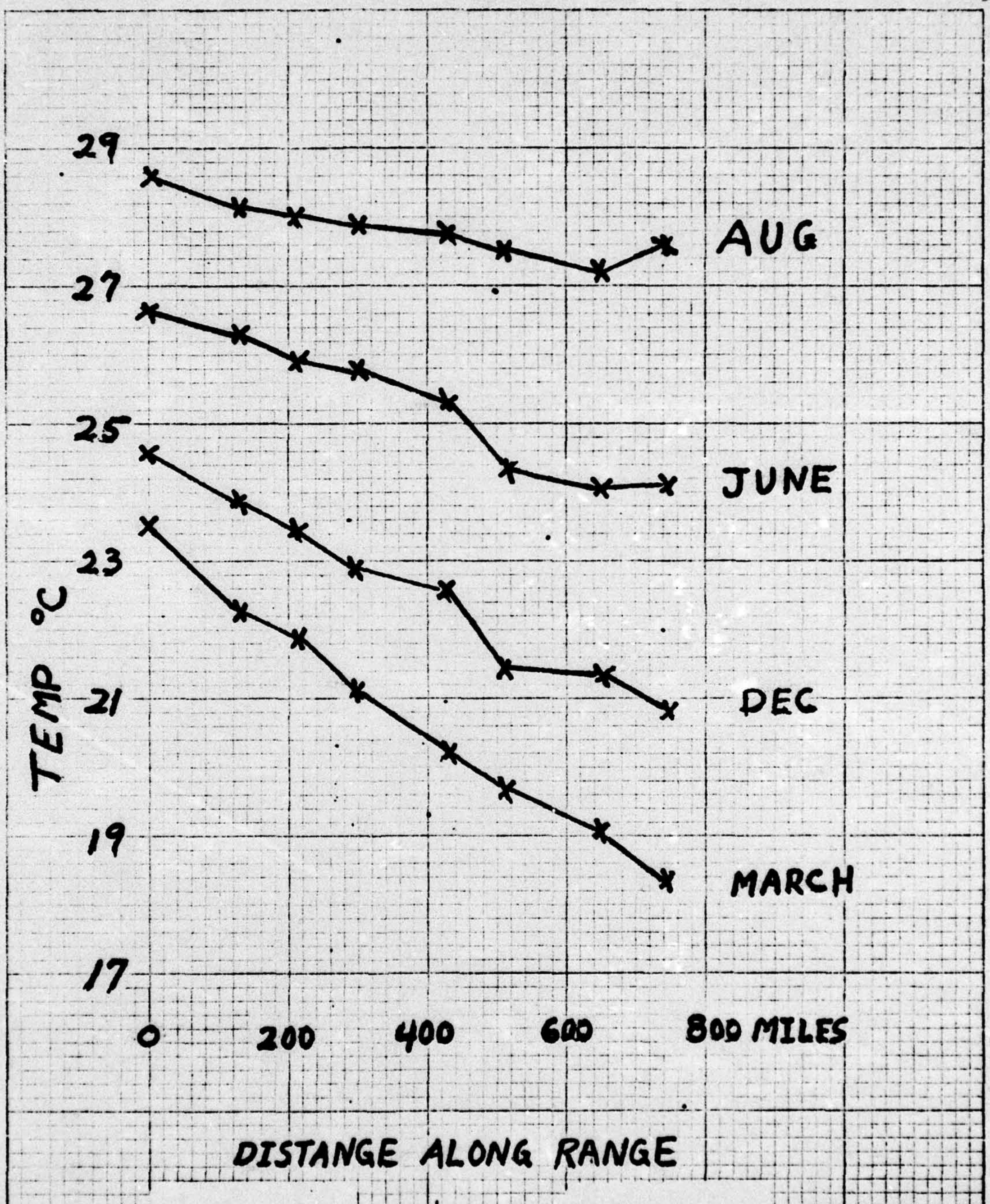

Figure 3

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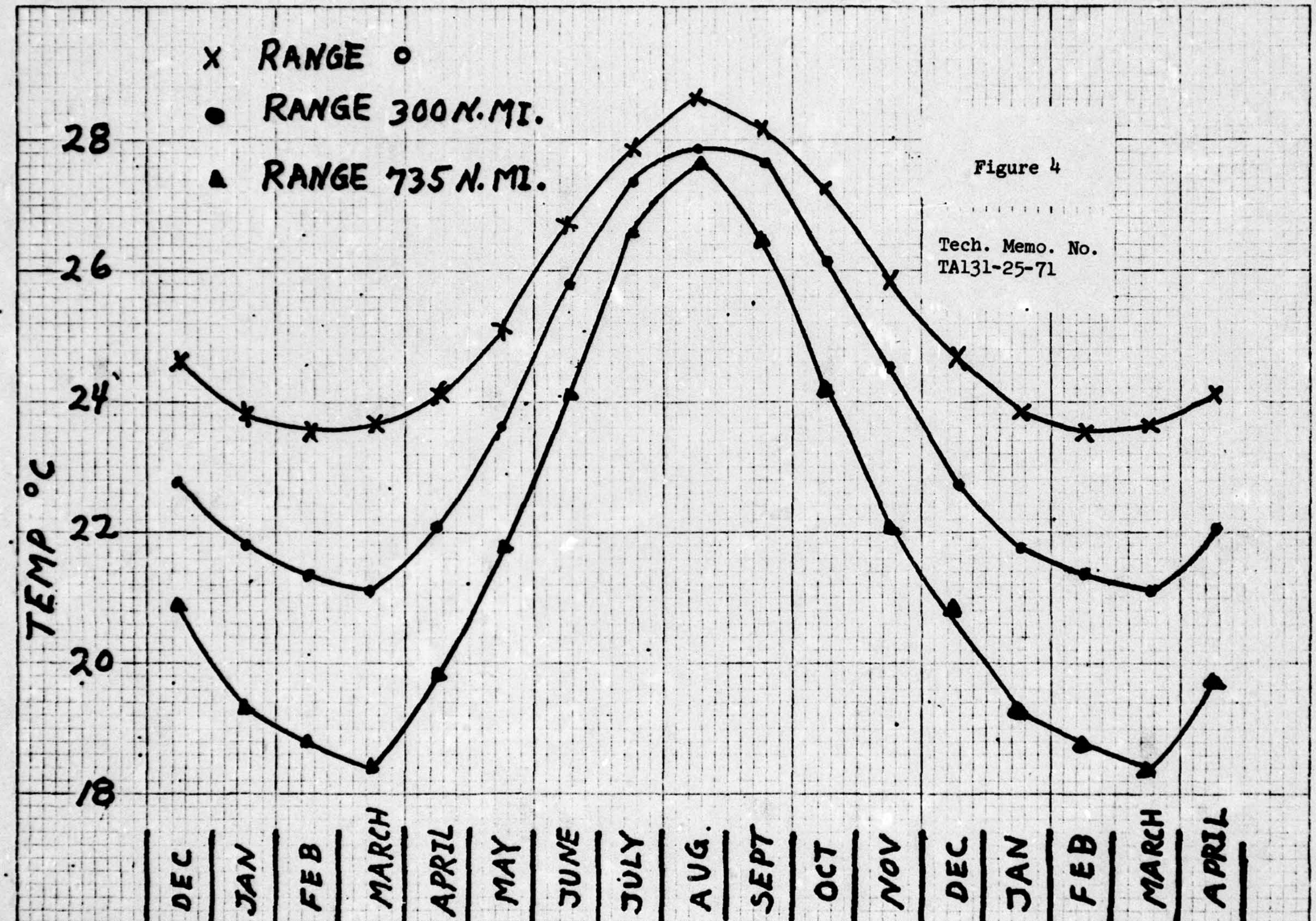

Figure 4

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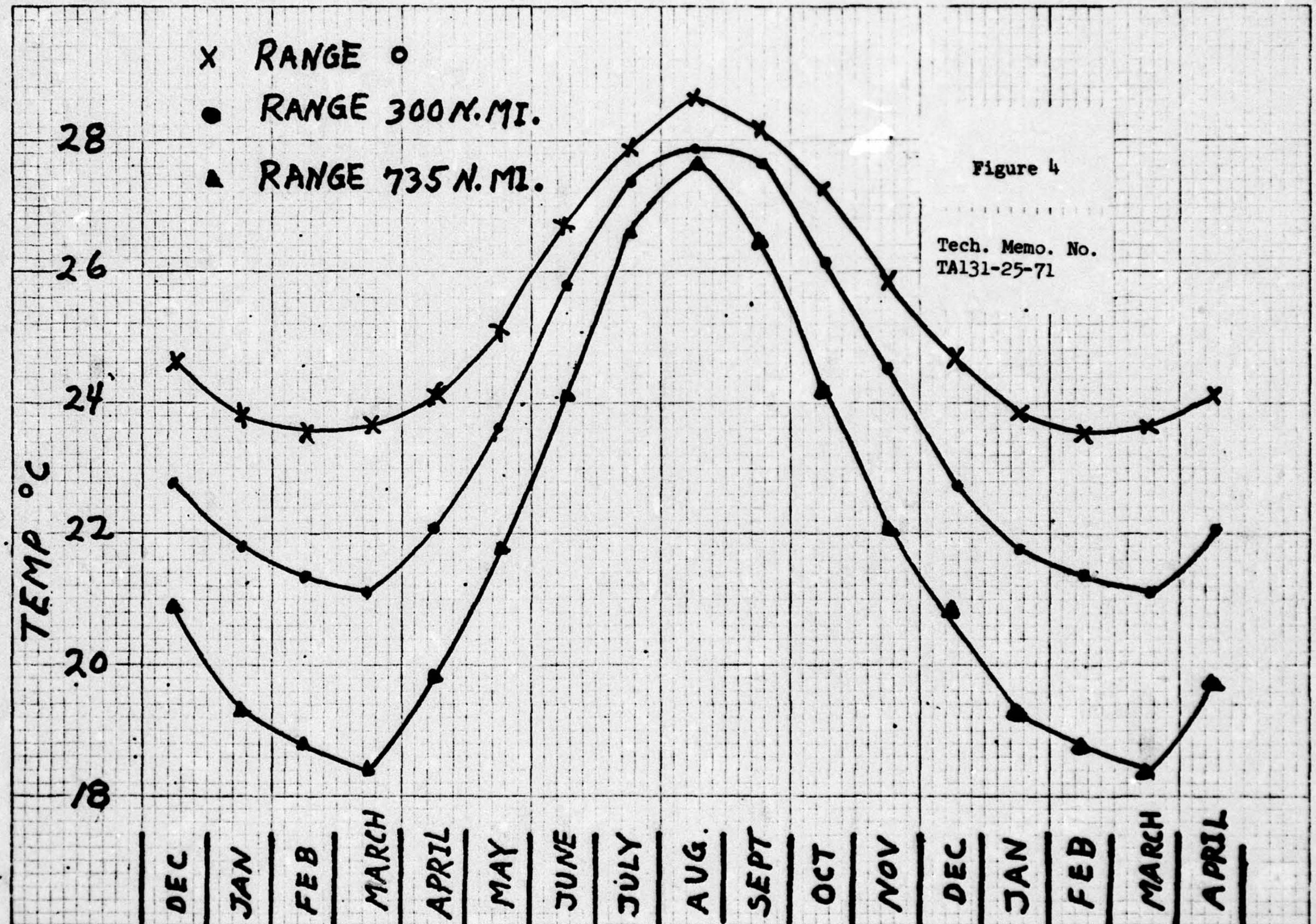

Figure 4

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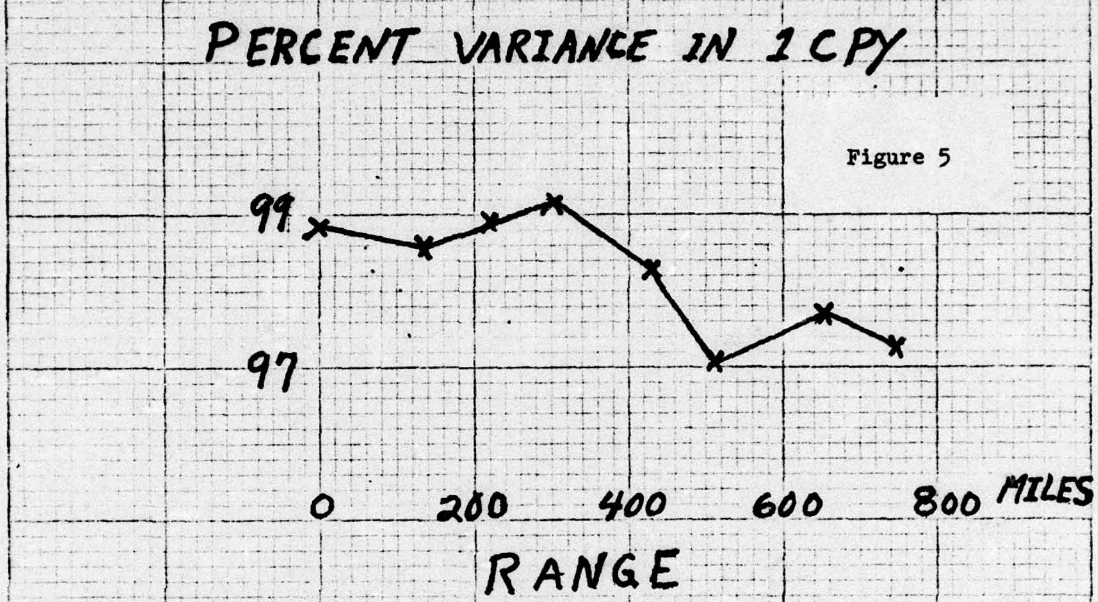

Figure 5

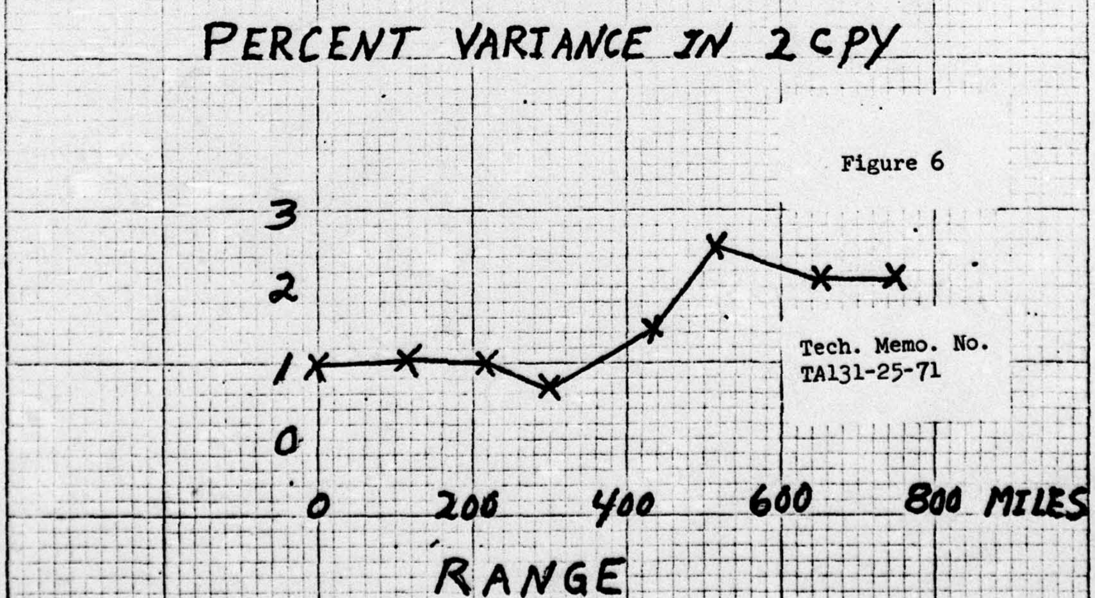

Figure 6

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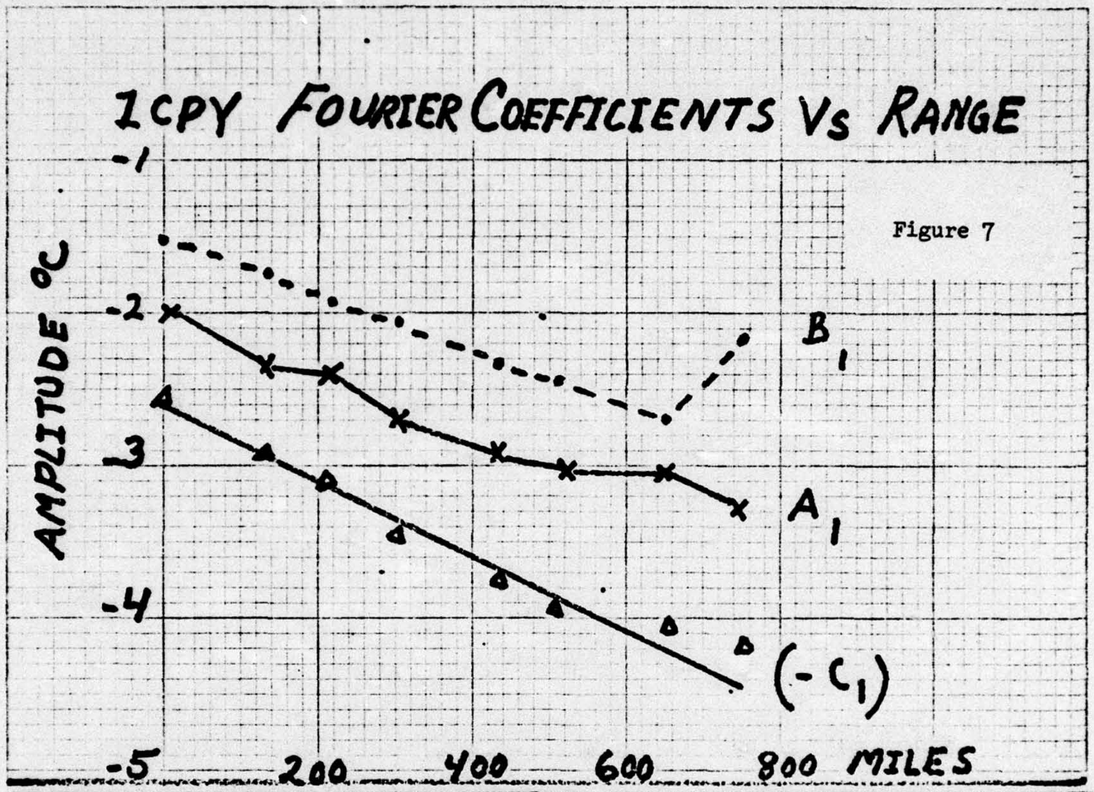

Figure 7

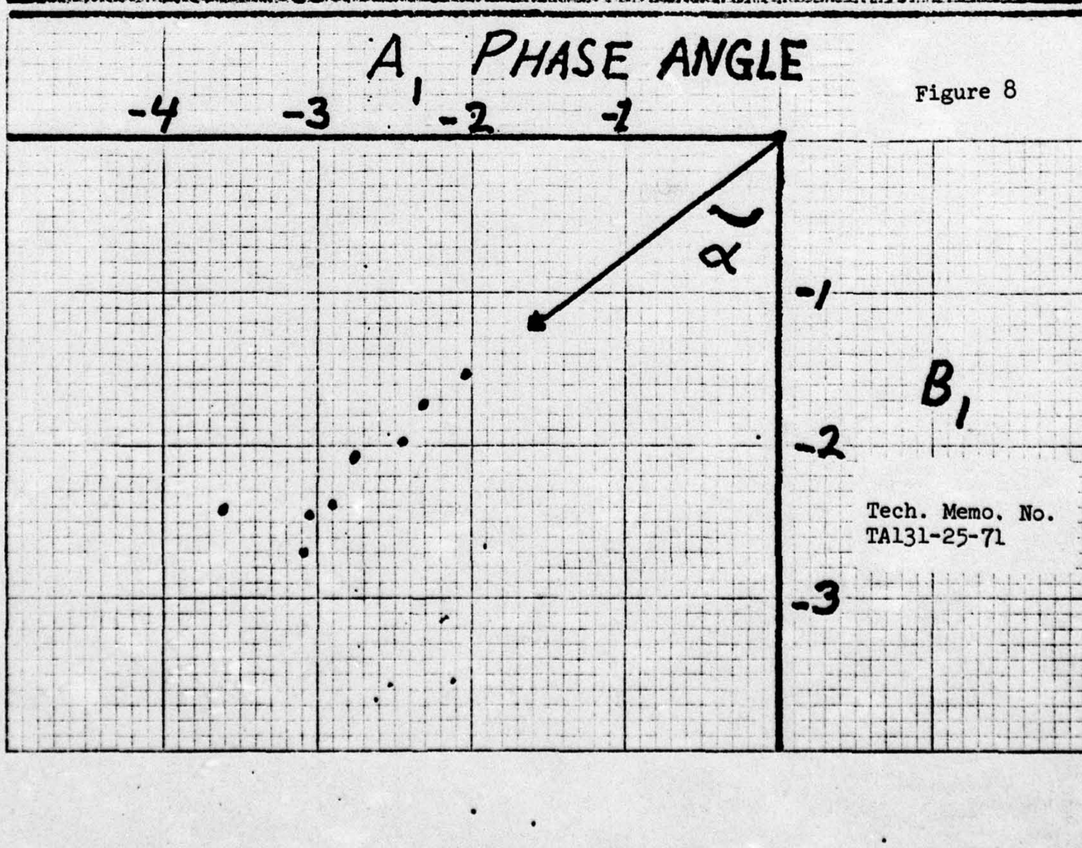

Figure 8

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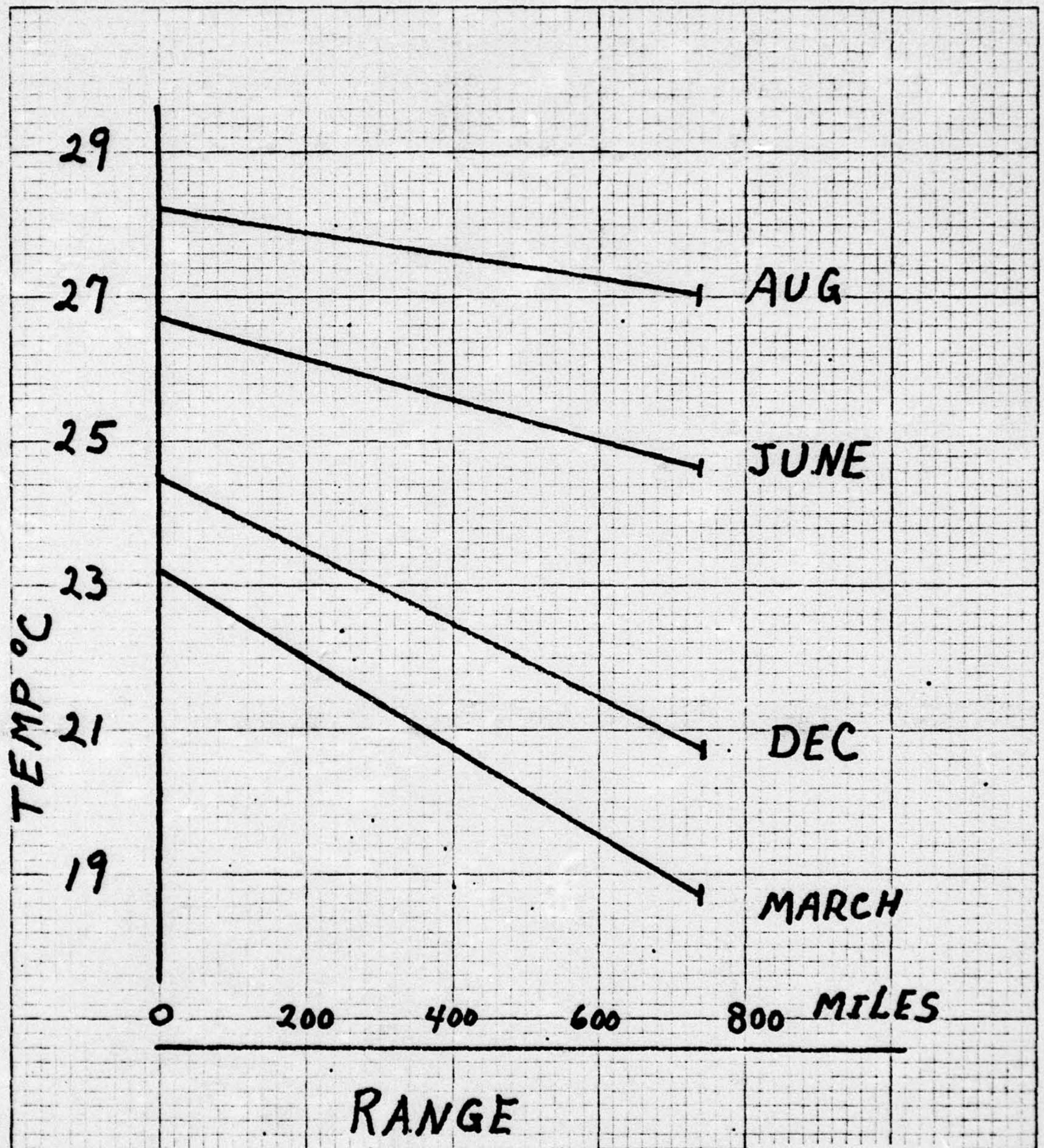

Figure 9

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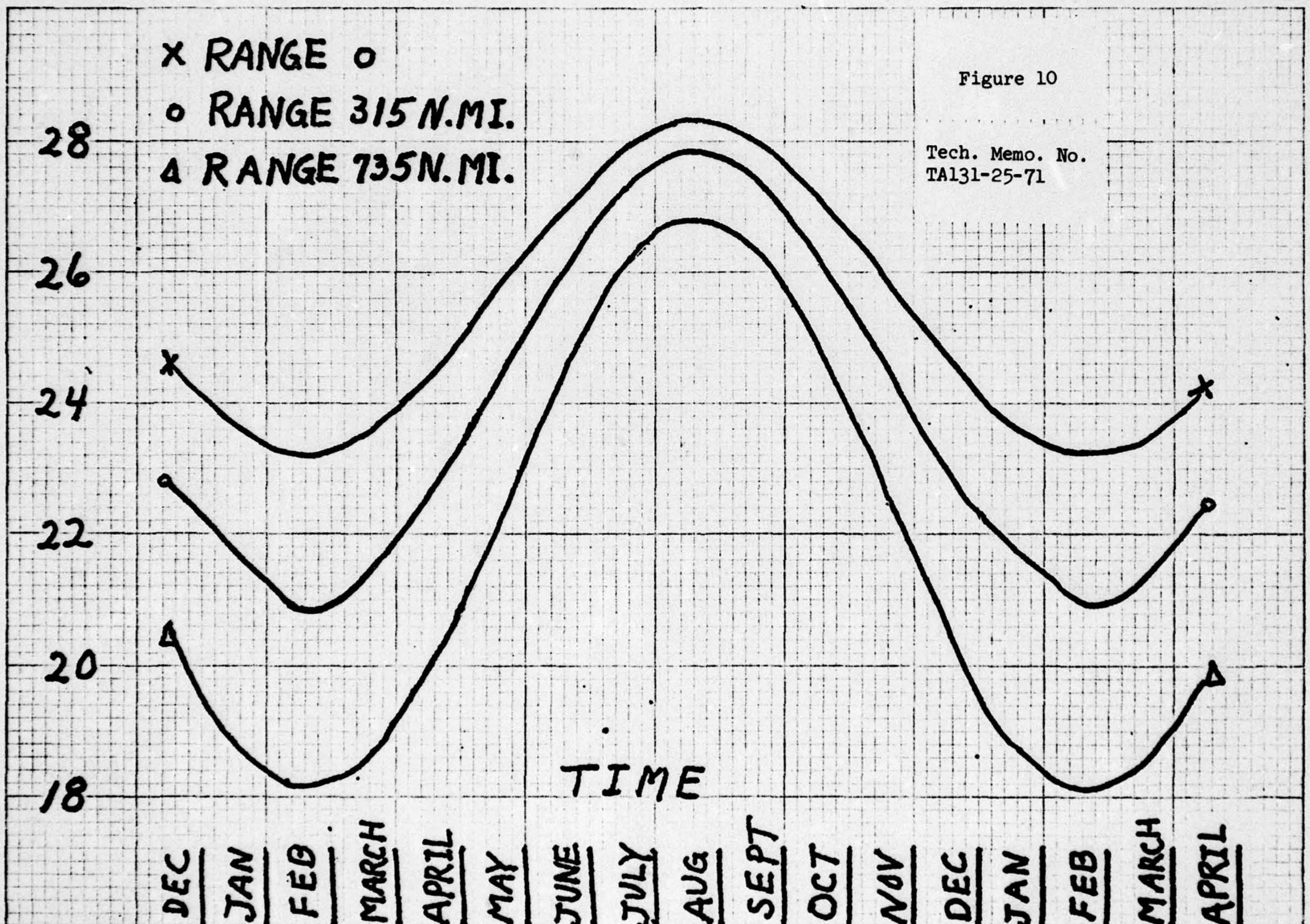

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Figure 10
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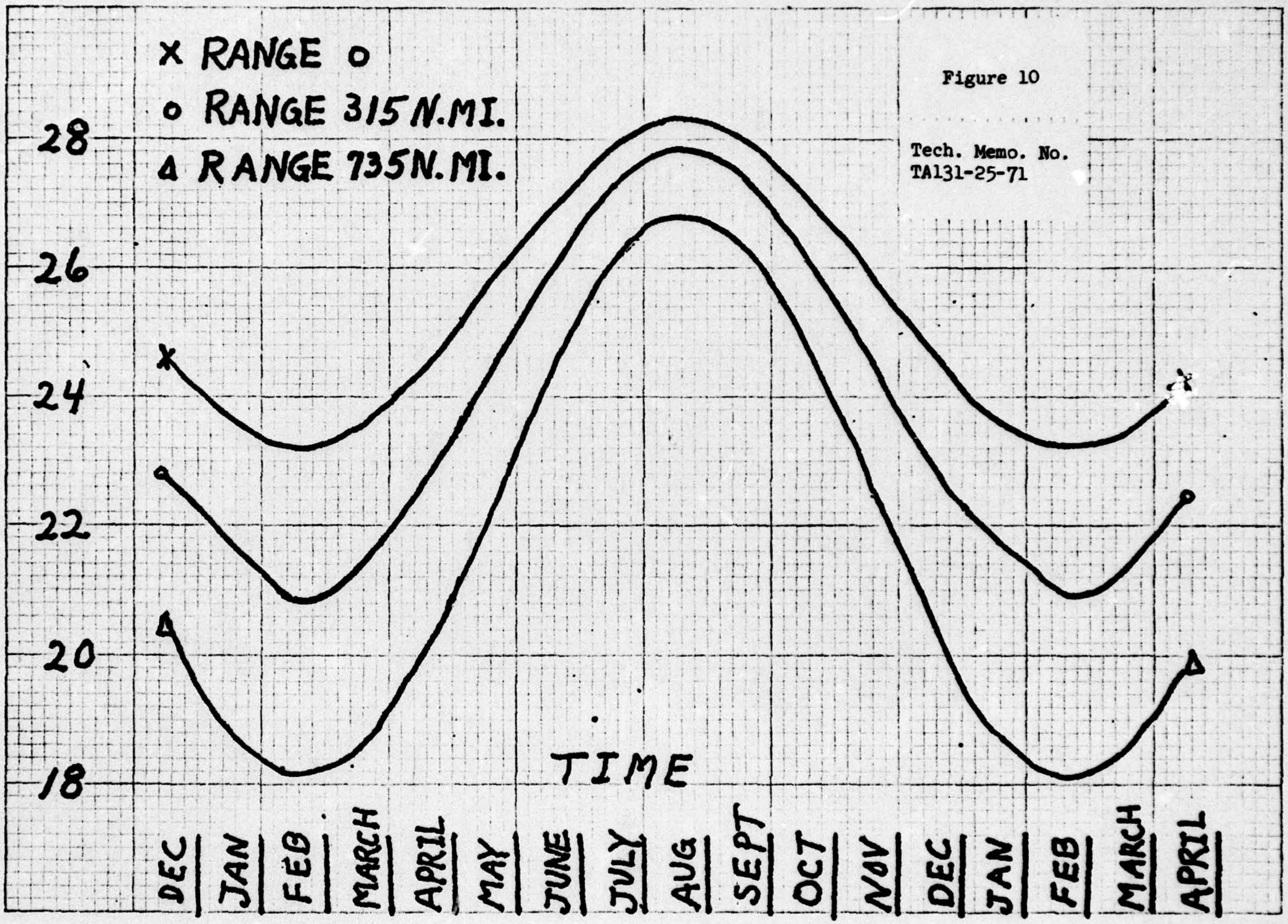

Figure 10

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